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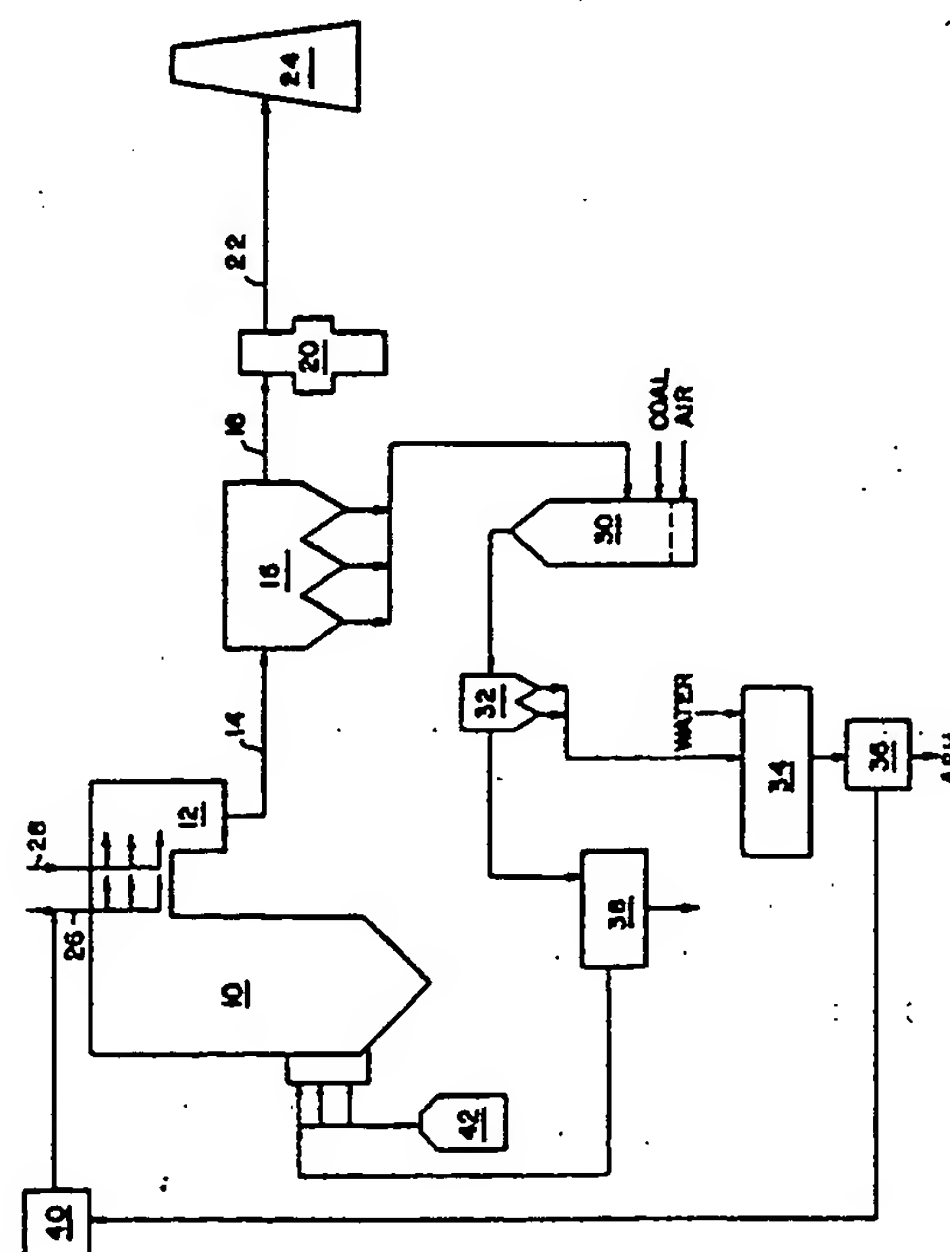
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54 Controlling emission of pollutants from coal-fired boiler systems.

57 In a method of controlling emission of  $\text{SO}_x$ ,  $\text{NO}_x$  and particulates from a coal-fired boiler system, that includes a boiler (10), an economiser (12) and a fabric filter baghouse (16), a reagent/catalyst in powdered form is added (26) into the combustion flue gas stream intermediate the boiler (10) and economiser (12) at a temperature below the melting point of the powder. The reagent/catalyst and ammonia (added at 28) are reacted with the  $\text{SO}_x$  and  $\text{NO}_x$  while the flue gas passes through the economiser (12). Further reaction is achieved as the gas is passed through a filter cake which forms on filter bags in the baghouse (16).



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## CONTROLLING EMISSION OF POLLUTANTS FROM COAL-FIRED BOILER SYSTEMS

This invention relates to controlling emission of pollutants from coal-fired boiler systems, for example in coal-fired electric power plants.

Advanced control technologies have rapidly evolved during the past two decades for dealing with emission from coal-fired power plants of particulates, sulphur oxides and nitrogen oxides.

A dramatic shift to low-sulphur coals, which produce high-resistivity fly-ashes, that are more difficult to collect, and the concurrent demand for increased particulate efficiency, has placed a heavy burden on conventional dust collectors (electrostatic precipitators) employed in these applications. Consequently, in the last 1970s the electric utility industry began, on a significant scale, to utilise alternative technology --fabric filterhouses-- for particulate control.

In a bag filterhouse (baghouse), fly-ash is separated from flue gas by filtration, i.e. the fly-ash is collected on the upstream side of tubularly shaped fabric filter bags as the gas is directed through the filter bags. The flue gas passes through a filter bag, typically from the inside out, and the fly-ash is collected as so-called filter cake. The material collected on the bag becomes part of the filtering medium. After a certain build-up of filter cake over the course of operation, the bags must be cleaned to avoid excessive pressure drop in order to maintain proper gas volume flow. The use of a bag filterhouse gives the utility company the option of switching coals since bag filterhouse collection efficiency is relatively insensitive to fuel characteristics.

Nevertheless, as coal burns, most of the sulphur content is converted to sulphur oxides ( $\text{SO}_x$ ), typically  $\text{SO}_2$  and  $\text{SO}_3$ . In addition, oxides of nitrogen (collectively referred to as  $\text{NO}_x$ ) are formed. Utilisation and placement of  $\text{NO}_x$  and  $\text{SO}_x$  control equipment upstream of the bag filterhouse will influence inlet conditions. Overall location of the bag filterhouse relative to such equipment, as well as the plant air heaters, flue gas temperature, flue gas composition, and fabric filter specifications including material properties such as composition, tensile strength, abrasion resistance, chemical resistance and temperature limitations, comprise the major parameters which must be carefully considered, integrated and controlled in order to achieve satisfactory overall plant emission control.

Our US Patent No. US-A-4 309 386 discloses a system in which a hot catalytic baghouse (greater than  $316^\circ\text{C}$  ( $600^\circ\text{F}$ )) is used for simultaneous particulate removal and  $\text{NO}_x$  reduction. According to US-A-4 309 386, filter bags of the baghouse are treated with a catalyst to facilitate a selective cata-

lytic reduction process while simultaneously filtering out particulate matter from the gas stream. The baghouse is situated downstream from an ammonia injection system. In the baghouse, the flue gas stream is exposed to the treated bags to effect  $\text{NO}_x$  removal. However, that system has several potential shortcomings. In particular, bags impregnated with the catalyst tend to have a limited life span, necessitating periodic replacement of the entire bag, and the catalyst is subject to  $\text{SO}_x$  poisoning which can lead to loss of ability to reduce  $\text{NO}_x$  in the presence of gases containing high quantities of  $\text{SO}_x$ .

Therefore, continuing improvements are being sought in emission control systems employing fabric baghouses with satisfactory control of  $\text{SO}_x$  and  $\text{NO}_x$  emissions.

According to one aspect of the invention there is provided an integrated injection and baghouse system which collects and removes  $\text{SO}_x$  and particulates from a flue gas stream while reducing  $\text{NO}_x$  to harmless  $\text{N}_2$ .

According to another aspect of the invention there is provided a method of controlling emission of pollutants from a coal-fired boiler system, which system includes a boiler, an economiser, a fabric filter baghouse and an air heater in a serial fluid communication path, by removing, in a temperature range of about  $316^\circ\text{C}$  to  $427^\circ\text{C}$  ( $600^\circ\text{F}$  to  $800^\circ\text{F}$ ),  $\text{SO}_x$ ,  $\text{NO}_x$  and particulates from a combustion flue gas stream passing through said path, the method comprising the steps of:

(a) adding a reagent/catalyst in powdered form and ammonia into the combustion flue gas stream upstream of the fabric filter baghouse in a temperature zone having a temperature below the melting point of the reagent/catalyst;

(b) reacting some of the reagent/catalyst and ammonia with the  $\text{SO}_x$  and  $\text{NO}_x$  to form reaction products while passing the flue gas stream to the baghouse;

(c) separating the particulates, the reaction products and reagent/catalyst from the flue gas within the temperature range by filtration in the baghouse to form a filter cake;

(d) passing the flue gas stream through the filter cake to react additional reagent/catalyst and ammonia with the  $\text{SO}_x$  and  $\text{NO}_x$  to form additional reaction products and cleansed gas; and

(e) venting the cleansed gas out of the baghouse through the air heater.

According to a further aspect of the invention, a suitable reagent/catalyst, such as sodium aluminate, is pneumatically injected into a boiler in fine powder form, in a temperature zone below the

melting point of the reagent/catalyst, upstream of a hot baghouse, which is operating in a temperature range of 600°F to 800°F (approximately 316°C to 427°C) and which is located between an exit of an economiser of the boiler and an air heater. Ammonia is also injected in this vicinity. A reaction between the NO<sub>x</sub> and ammonia converts the NO<sub>x</sub> to harmless nitrogen gas and a reaction between SO<sub>x</sub> and the reagent produces a solid particulate which continues to flow with the flue gas. The mixture of reactants, reaction products, and flue gases continues to flow to the baghouse, where the particulates are separated from the flue gas.

The injection technique advantageously provides an extended time for reaction of the reagent/catalyst and the SO<sub>x</sub> and NO<sub>x</sub> as the flue gas stream flows from the injection point to fabric filter bags of the baghouse. Further reaction takes place as the solids are collected in the filter bags as filter cake and the flue gases continue to pass through the filter cake.

In accordance with a preferred feature of the invention, the reagent/catalyst is removed from the baghouse, along with the fly-ash, for regeneration. Poisoning of the catalyst with SO<sub>x</sub> is no longer a problem since the method seeks to achieve reaction of the reagent/catalyst with SO<sub>x</sub> to remove the sulphur oxides from the gas stream and the reaction is otherwise acceptable due to the continuous replenishment of the reagent/catalyst by regeneration.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawing, the sole figure of which is simplified flow diagram illustrating a preferred arrangement for carrying out a method embodying the invention.

The drawing shows a coal-fired boiler 10 that includes an economiser 12 which is designed, as is well known, to remove heat from the combustion flue gases after the gases leave steam-generating and superheating sections of the boiler 10. An outlet of the economiser 12 is connected through a flue gas conduit 14 to a baghouse 16 in which particulates are collected in filter bags (not shown). The treated gas is discharged from the baghouse 16 through a conduit 18 to an air preheater 20 and then through a conduit 22 to a stack 24 for ultimate discharge to the atmosphere.

Injection lines 26, 28 are provided for injecting a solid reagent/catalyst and ammonia (NH<sub>3</sub>), respectively, into a zone, having a temperature below the reagent/catalyst melting point, upstream of the baghouse 16. For example, as shown in the drawing, the solid reagent/catalyst and ammonia are injected upstream of the economiser 12, i.e. intermediate the boiler 10 and economiser.

Pneumatic injection of the reagent/catalyst, via

wall injectors, is preferred. The ammonia is preferably injected between a primary superheater and the economiser 12 as placement further upstream would result in excessive loss of ammonia by oxidation. The temperature at the economiser inlet will typically be between 371°C and 538°C (700°F and 1000°F), and the preferred operating range is 316°C to 427°C (600°F to 800°F). Reagents are selected which will not react with ammonia in this temperature range.

The combustion flue gas, which contains particulates, SO<sub>x</sub> and NO<sub>x</sub>, reacts with the reagent/catalyst as it flows through the economiser 12 and to the baghouse 16. As the gas flows from the injection point through the baghouse 16, the catalyst reacts with SO<sub>x</sub> and NO<sub>x</sub> and ammonia. The catalyst reacts further as it collects in the filter bags and the flue gas passes through it.

Sodium aluminate is the preferred reagent/catalyst. Other reagent/catalysts include transition metal oxides of titanium, vanadium, manganese, cobalt, iron, nickel, copper and zinc; alumina (particularly gamma phase) and alkalis alumina; alkali and alkaline earth oxides and carbonates; and minerals such as dawsonite, analcite, magnesioriebeckite, feldspars, alunite, anatase, azurite, bauxite, bunsenite, gothite, hematite, iron spinel, ilmenite, malachite, manganite, manganosite, mellite, siderite, and spinel.

The spent reagent/catalyst material is removed from the baghouse 16 with the fly-ash. The spent material contains sulphur from the flue gas in the form of sulphates and sulphites. The spent material and fly-ash are then fed into a fluid bed gasifier 30 where coal is added as a fuel source and the temperature of the sulphated spent material is raised to a level where the sulphur is driven off in the form of sulphur dioxide and hydrogen sulphide. The reagent/catalyst is then removed from the gas stream with the fly-ash via a particulate collector 32, such as a secondary baghouse, precipitator, or high efficiency cyclone. The collected solids are then added to water in a mixing tank 34 to form a slurry. The reagent/catalyst goes into solution. The slurry is then directed to a solid separator 36, such as a belt filter or centrifuge, where the ash is removed from the system. The solution containing the regenerated reagent/catalyst is then recycled as make-up back to the boiler 10. A drier 40 may be required prior to injecting the reagent/catalyst into the boiler.

The spent gas from the fluid bed gasifier 30 may be taken to a Klaus plant 38 where the SO<sub>2</sub> and H<sub>2</sub>S may be recovered in the form of elemental sulphur. A portion of the steam produced in the fluid bed gasifier 30 may be used for the operation of the Klaus plant 38. The low J (Btu) gas would then be sent back to the boiler 10 as additional fuel

with pulverised coal from a pulveriser 42 or could be used for other plant process requirements. There is a possibility that this gas could be used in the production of ammonia which in turn could be used as the make-up for the NO<sub>x</sub> reduction process.

### Claims

1. A method of controlling emission of pollutants from a coal-fired boiler system, which system includes a boiler (10), an economiser (12), a fabric filter baghouse (16) and an air heater (20) in a serial fluid communication path, by removing, in a temperature range of about 316°C to 427°C (600°F to 800°F), SO<sub>x</sub>, NO<sub>x</sub> and particulates from a combustion flue gas stream passing through said path, the method comprising the steps of:

(a) adding (26,28) a reagent/catalyst in powdered form and ammonia into the combustion flue gas stream upstream of the fabric filter baghouse (16) in a temperature zone having a temperature below the melting point of the reagent/catalyst;

(b) reacting some of the reagent/catalyst and ammonia with the SO<sub>x</sub> and NO<sub>x</sub> to form reaction products while passing the flue gas stream to the baghouse (16);

(c) separating the particulates, the reaction products and reagent/catalyst from the flue gas within the temperature range by filtration in the baghouse (16) to form a filter cake;

(d) passing the flue gas stream through the filter cake to react additional reagent/catalyst and ammonia with the SO<sub>x</sub> and NO<sub>x</sub> to form additional reaction products and cleansed gas; and

(e) venting the cleansed gas out of the baghouse (16) through the air heater (20).

2. A method according to claim 1, wherein the reagent/catalyst is sodium aluminate.

3. A method according to claim 1, wherein the reagent/catalyst is selected from metal oxides of titanium, vanadium, manganese, cobalt, iron, nickel, copper and zinc.

4. A method according to claim 1, wherein the reagent/catalyst is selected from alumina and alkalised alumina.

5. A method according to claim 1, wherein the reagent/catalyst is selected from alkali and alkaline earth oxides and carbonates.

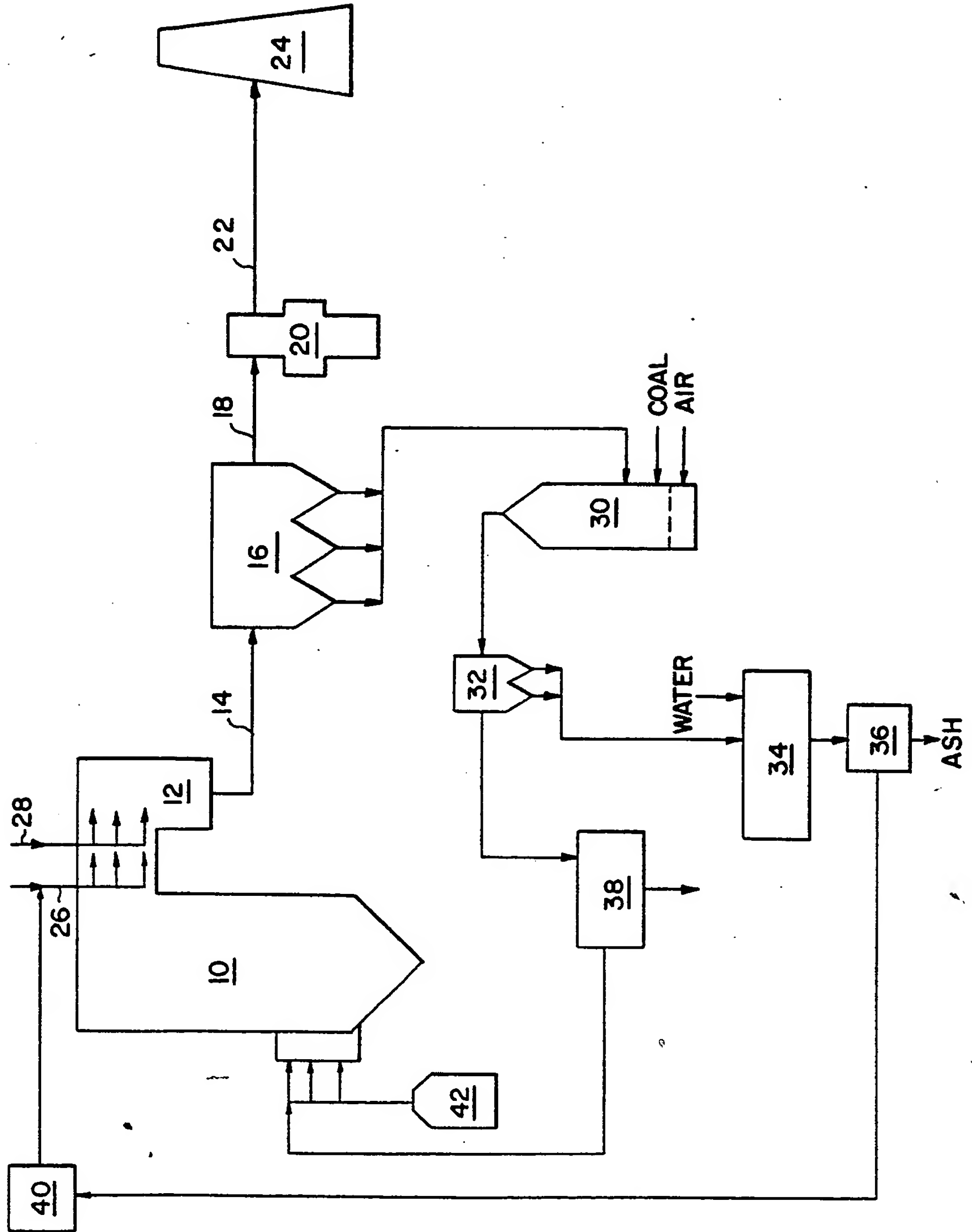
6. A method according to claim 1, wherein the reagent/catalyst is selected from dawsonite, analcite, magnesioriebeckite, feldspar, alunite, anatase, azurite, bauxite, bunsenite, gothite, hematite, iron spinel, ilmenite, malachite, manganite, manganosite, mellite, siderite and spinel.

7. A method according to any one of the preceding claims, wherein the adding step (a) comprises adding the reagent/catalyst intermediate the boiler (19) and the economiser (12).

8. A method according to claim 7, wherein the reacting step (B) comprises reacting some of the reagent/catalyst and ammonia with the SO<sub>x</sub> and NO<sub>x</sub> to form reaction products while passing the flue gas stream through the economiser (12) to the baghouse (16).

9. A method according to any one of the preceding claims, comprising reclaiming reagent/catalyst from the cake by heating (30) the cake to a temperature sufficient to volatilise and drive off sulphur dioxide and hydrogen sulphide from the cake and form remaining solids containing recoverable reagent/catalyst, and separating (32) the recoverable reagent/catalyst from the solids, and wherein the adding step (a) includes passing the recovered reagent/catalyst into the combustion gas stream.







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# EUROPEAN SEARCH REPORT

Application Number

EP 87 30 7884

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A,P	EP-A-0 217 733 (MITSUBISHI JUKOGYO K.K.) * claims 1-3 *	1,4,5	B 01 D 53/34
A	US-A-4 464 350 (M.L. KAPLAN) * claims 1, 3, 5-7 *	1,3	
A	DE-A-3 235 020 (H. HÖLTER) * claim 1; page 4, lines 12-16 *	1,5	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 01 D 53/00
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 12-01-1988	Examiner BERTRAM H E H
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			